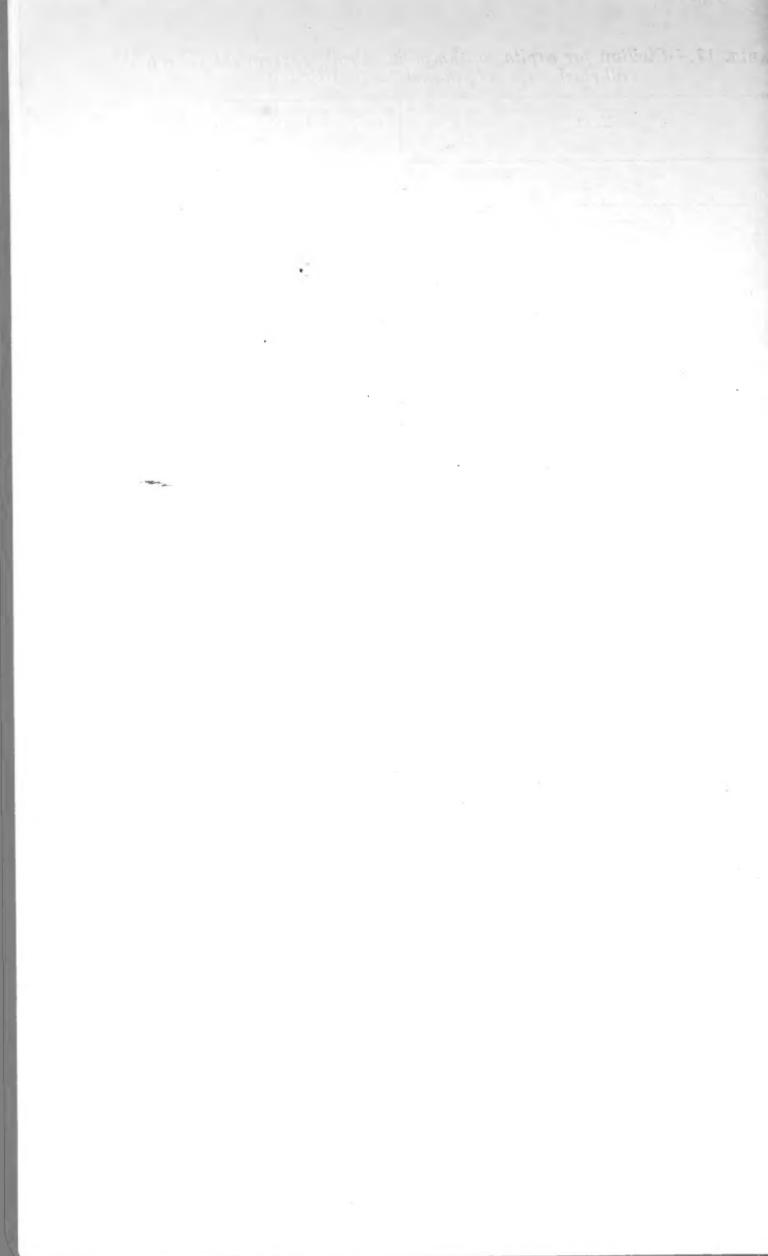
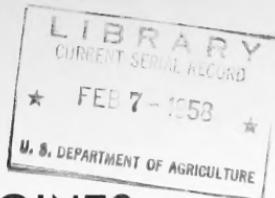


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FREEZING POINTS of FRUITS, VEGETABLES and FLORIST STOCKS

Freezing Points of

Marketing Research Report No. 196

U. S. DEPARTMENT OF AGRICULTURE
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FREEZING POINTS OF FRUITS, VEGETABLES, AND FLORIST STOCKS¹

By T. M. WHITEMAN, *horticulturist, Biological Sciences Branch,
Marketing Research Division*

Summary

Freezing points were determined for the principal fruits, vegetables, and florist stocks. The data can provide a guide that growers, shippers, storage operators, and others concerned with the marketing of these commodities can use to minimize or avoid freezing damage and losses.

The freezing points of some living products may approach 32° F., the freezing point of water, but they never reach this point. In the tests reported, the freezing points of most fruits ranged from 27° to 30° and of most vegetables from 29° to 31°. Freezing points of florist stocks varied widely, depending to a great extent on the part of the plant tested.

This report is concerned only with the temperatures at which various products may freeze. It should be emphasized that many commodities may be injured by temperatures considerably above their freezing points, a few even when stored at a temperature as high as 55° F.

Introduction

The temperatures at which perishable commodities may be injured by freezing in the field, in storage, or during transit and marketing are of practical concern to the many who grow and handle fruits, vegetables, and florist stocks.

Killing frosts or freezes during the growing or harvesting season cause extreme concern to the growers of many horticultural crops. Fruits, vegetables, and flower crops are occasionally frozen in the field and rendered unfit for shipment. At times they may also be damaged by freezing en route to their destinations. It is therefore evident that knowledge of the temperatures at which the various products are likely to freeze is important to growers, shippers, carriers, and receivers. Since certain products are stored either before shipment or at destination, storage warehousemen too must be alert in their control of storage rooms, especially those held at about 32° F., to see that temperatures do not accidentally fall below the freezing point of the commodity stored. Knowledge of the freezing point of a product

¹ This marketing research report is a revision of and supersedes USDA Circular 447, "The Freezing Temperatures of Some Fruits, Vegetables, and Florists' Stocks," revised 1942, by R. C. Wright.

provides a definite guide in determining whether inspections for freezing damage are necessary.

However, the freezing point of a commodity is not necessarily an indication of the damage that might be expected from low temperatures, as certain horticultural crops are susceptible to cold injury by temperatures that are not low enough to freeze them, while a few may be frozen and thawed a number of times without injury.²

There is always the possibility that a product may freeze during the marketing period after its arrival at destination or removal from storage. Freezing of produce should be constantly guarded against at the terminal markets, at both wholesale and retail levels. Here again, operating personnel in these establishments who know the freezing points can use them as danger points near which damage may occur.

Requests for information have indicated considerable interest in freezing points. About 600 freezing points are reported here, including those for 37 kinds and varieties of citrus fruits, 19 apple varieties, 11 varieties of pears, 11 kinds or varieties of grapes, 15 varieties of avocados, 11 varieties of potatoes, the roots of 10 sweetpotato varieties, and many other kinds and varieties of fruits, vegetables, and florist stocks. In many instances, freezing points were determined for a commodity and for different parts of that commodity, such as peel and flesh of bananas, tops and roots of beets, flesh and rind of citrus fruits, and strawberries and crowns and roots of strawberry plants as customarily stored. Standard commercial varieties as well as some newer ones were selected for these studies.

Equipment and Methods

Freezing points were determined with a 20-point electronic recording potentiometer using 24-gage wire for the standard, twisted-wire, copper-constantan thermocouples (figs. 1 and 2). With this equipment, the temperature changes before, during, and after freezing for either 10 or 19 specimens or composite samples of 1 kind or variety were obtained simultaneously. The freezing point of each of these specimens or unit samples was determined separately, and from these findings the average, lowest, and highest freezing points are given in tables 1, 2, 3, and 4. In most cases, the products were frozen in a room held at 21° to 22° F.

During this freezing-point work, the potentiometer was set to register every 30 seconds, recording the temperature of each of the 20 individual thermocouples every 10 minutes. The rated accuracy of the instrument was $\pm 0.3^{\circ}$ F. One thermocouple was used as a constant check on the accuracy of the instrument. It was put in a small glass tube (containing about 3 inches of mercury) which along with a thermometer, was placed in a thermos bottle filled with a distilled-water ice and distilled-water mixture giving a temperature of 32°, the mixture being renewed daily. The instrument was adjusted, whenever required, so that the reference thermocouple maintained 32°, $\pm 0.1^{\circ}$. Periodically, the thermocouples were calibrated in

² For recommended storage conditions for various commodities, see WRIGHT, R. C., ROSE, DEAN H., and WHITEMAN, T. M. THE COMMERCIAL STORAGE OF FRUITS, VEGETABLES, AND FLORIST AND NURSERY STOCKS. U. S. Dept. Agr. Handbook No. 66, 1954.

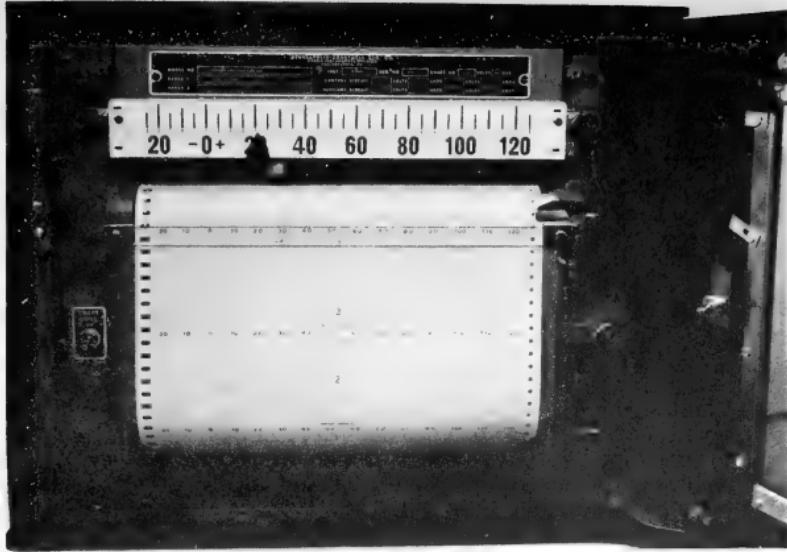


FIGURE 1.—Recording potentiometer used in freezing-point determinations.

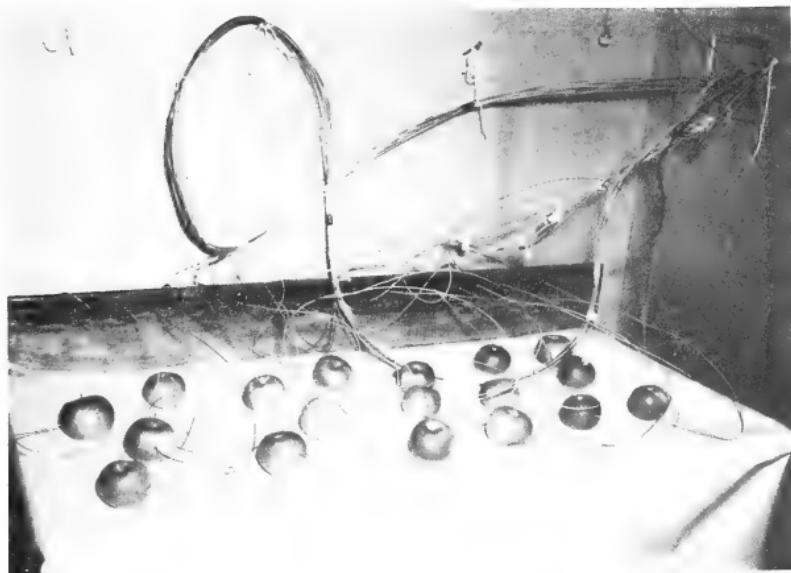


FIGURE 2.—Method of determining freezing points with thermocouples, showing these inserted to a depth of one-half inch in apples.

mercury at 32° and the instrument was checked against a precision potentiometer.

The percentages of soluble solids of the juice of a number of products were determined with laboratory and hand refractometers. The pH values were determined by the glass electrode method. Whenever the relation between soluble solids and freezing points is discussed, the average freezing points are used, since the juice used to determine soluble solids was a composite sample.

The temperature of a product may be lowered below its freezing point without freezing taking place; that is, without the formation of ice crystals. This is known as supercooling. When a commodity is supercooled, any sudden jarring may cause it to freeze. In commercial storage, if this occurs accidentally it is desirable to raise the room temperature and avoid disturbing the commodity. Doors should be closed gently and floors should not be jarred by the rolling about of heavy objects. These precautions minimize freezing damage, because the individual specimens that have been supercooled may warm up without ice being formed in their tissues.

In determining freezing points, supercooling may or may not occur. As freezing begins, latent heat is released, and usually the temperature rises rapidly, sometimes to a peak temperature slightly above the freezing point. The rise in temperature is then followed by a plateau or "leveling off" period of varying length during which the temperature of the tissue surrounding the thermocouple is constant. Usually the first constant temperature is taken to be the freezing point of the product.

Satisfactory freezing points were obtained with specimens of $2\frac{1}{4}$ inches and over in diameter without special preparations. Individual specimens as small as limes or plums were wrapped in several thicknesses of aluminum foil. Items such as cranberries or grapes were cut or chopped and placed in hand-made aluminum foil balls $2\frac{1}{4}$ inches in diameter and squeezed to eliminate air spaces. Leaves of low moisture content and fluffy products such as acacia flowers were made into aluminum foil bundles at least $2\frac{1}{4}$ inches in diameter and wrapped very tightly with twine in order to exclude as much air as possible. Thermocouples were always inserted to a depth of not less than one-half inch to avoid having them too close to the cold room air.

Results

Highest Freezing Point a Guide to Freezing Injury

In certain species, such as oranges, the freezing points of different varieties vary to such an extent that an average freezing point for the species would be of questionable value. The mean freezing point of the flesh of all varieties and lots of oranges tested was 28.5° F. within extremes of 26.7° and 30.3° (table 1). It is obvious that each variety should be considered separately because 28.5° [$\pm 1.8^{\circ}$] as an average freezing point for oranges would be of little worth.

The range in "highest" freezing points obtained for the varieties of each species is given for most of the important fruits and vegetables. For example, the flesh of Lue Gim Gong oranges had freezing points as follows: Average 26.7° F., lowest 25.9° , and highest 27.4° . Freezing points of the flesh of Hamlin oranges were: Average 29.4° , lowest 28.2° , and highest 30.6° . Hence, the range in highest freezing points for

the 14 varieties of oranges was 27.4° to 30.6° . Some freezing damage may occur within this range for the orange varieties tested, but the likelihood of injury to any one variety is more accurately based on the highest freezing point obtained for that variety.

Freezing Points of Fruits

Table 1 lists more than 300 freezing-point determinations for about 60 kinds of fruits.

One or more samples of the following fruits had highest freezing points between 27.0 and 27.9° F.: Cherry (sweet), grape, orange (rind), and pear. Fruits with freezing points between 28.0° and 28.9° were apple, banana (flesh, ripe), coconut (flesh), grapefruit (rind), lime, orange (flesh), orange (rind), and pear. Freezing points of the following fruits ranged from 29.0° to 29.9° : Apricot, banana (flesh, ripe), blueberry, cherry (sour), cranberry, grapefruit (flesh), lemon, mango, nectarine, orange (flesh), pear, plum, and tangelo. Fruits with freezing points ranging from 30.0° to 30.9° were avocado, banana (flesh, green), blackberry, cranberry, gooseberry, nectarine, papaya, peach, pineapple, raspberry, strawberry, and tangerine.

APPLE

The range in highest freezing points of the 19 varieties of apples was 27.2° to 30.0° F. as shown in table 1. The Stayman and Winesap apples had the lowest average freezing points and also the highest percentages of soluble solids. The relation between average freezing points and soluble solids was not consistent for the apple varieties as a group.

AVOCADO

The range in highest freezing points of 15 varieties of avocados was 29.1° to 31.5° F. The degree of ripeness of the avocados influenced the freezing points considerably. The highest freezing points of the hard-ripe, eating-ripe, and soft-ripe fruits of the Booth 7 variety were 30.0° , 30.4° , and 31.5° , respectively.

BANANA

Freezing points were determined for Gros Michel and Plantain bananas. The 5 samples of Gros Michel fruits were from different sources.

The range in highest freezing points of the flesh of green bananas was 30.0° to 30.6° F.; the range for the flesh of firm-ripe and ripe fruits was 28.8° to 29.4° . The range in highest freezing points of the peel of green bananas was 30.8° to 31.0° and of the peel of firm-ripe and ripe fruits 30.0° to 30.3° . Soluble solids increased markedly in both the flesh and the peel during ripening.

CHERRY

The range in highest freezing points of the 3 varieties of sweet cherries was 26.5° to 28.8° F. The highest freezing point of the Montmorency cherry was 29.0° . The soluble solids were 16.6 to 22.5 percent for the sweet cherry varieties and 6.8 percent for the sour variety. The Bing variety had the highest soluble solids and

the lowest average freezing point (26.2°), whereas the Montmorency variety had the lowest soluble solids and the highest average freezing point (28.9°).

GRAPE

The range in highest freezing points of 10 European or vinifera grape varieties was 26.7° to 28.1° F. The freezing points of the European type of grapes were in general lower than those of the American or labrusca type. Differences in freezing points may have been due to higher soluble solids in the European varieties.

GRAPEFRUIT

The ranges in highest freezing points of 5 important varieties of Florida grapefruit were 28.9° to 30.0° F. for the flesh and 26.9° to 29.7° for the rind. The highest freezing points of the flesh were 0.3° to 2.0° higher than those of the corresponding rind in 8 out of 9 instances. The soluble solids of the rind were higher than those of the flesh.

MANGO

The highest freezing points of 5 varieties of mangos ranged from 29.4° to 30.3° F. The hard-ripe fruits were somewhat higher in freezing points, lower in pH values, and lower in soluble solids than ripe fruits.

NECTARINE

The highest freezing points of the Quetta variety of nectarine were 30.1° F. in hard-ripe fruits and 29.3° in firm-ripe fruits. The average freezing points were 29.8° in hard-ripe fruits and 28.8° in firm-ripe fruits. Soluble solids of hard-ripe and ripe fruits were 9.3 and 13.1 percent, respectively. The highest freezing point recorded for the John River variety was 30.4° .

ORANGE

The highest freezing points of the flesh of 14 varieties of oranges ranged from 27.4° to 30.6° F. The freezing points of the flesh were higher than those of the rind in practically all instances. The soluble solids of the rind of Jaffa (lot 1) and Washington Navel oranges (lot 1) were 4.0 and 3.7 percentage points greater, respectively, than those of the flesh. The soluble solids of the rind of Honey Murcott oranges were 8.8 percentage points higher than those of the flesh.

The highest freezing point of leaves of Florida Valencia orange trees was 28.7° F.

PEACH

The highest freezing points of 5 varieties of peaches ranged from 29.4° to 30.3° F.

PEAR

The highest freezing points of 11 varieties of pears ranged from 26.7° to 29.2° F. In general, the average freezing points decreased as the soluble solids increased, but there was no consistent relation between these factors.

PINEAPPLE

The range in highest freezing points of 4 varieties of pineapples was 29.5° to 30.2° F. There was no consistent relation between soluble solids and average freezing points. Although the differences appear small, the average freezing points increased consistently with increases in active acidity (decreases in pH values).

PLUM

The range in highest freezing points of 9 varieties of plums was 27.7° to 30.5° F. The varieties with the highest soluble solids had the lowest average freezing points.

STRAWBERRY

The range in highest freezing points of 19 varieties of strawberries was 29.8° to 30.6° F. Soluble solids ranged from 6.1 to 10.1 percent in the ripe fruits of these varieties. The average freezing points were only slightly lower than the highest freezing points. There was no relation between average freezing points and soluble solids. The Fairfax variety had the lowest average freezing point and next to the highest soluble solids.

Freezing points, soluble solids, and pH values were determined for green and ripe berries of Blakemore, Midland, and Pocahontas varieties. Soluble solids were higher in the ripe fruits than in the green fruits, but the average freezing points of the ripe berries were lower than those of the green ones only in the Midland variety.

TANGELO

The highest freezing points of the flesh of 4 varieties of tangelos ranged from 28.0° to 30.3° F., and those of the rind from 26.4° to 29.0°. The average freezing points of the flesh of these varieties were higher than those of the rind. Soluble solids and pH values of the flesh were lower than those of the rind.

Freezing Points of Vegetables

Freezing points were determined for about 50 kinds of vegetables (table 2).

One or more samples of the following vegetables had highest freezing points between 29.0 and 29.9° F.: Artichoke (globe), beets, broccoli (buds), carrots, garlic (dry bulbs), horseradish roots, leek (stalk), muskmelon (2 kinds), okra, peas (garden), shallot (dry bulbs), squash (1 variety), and sweetpotatoes (cured). Vegetables with highest freezing points between 31.0° and 31.9° were: Bean (lima, shelled), beet tops, broccoli rabi, cabbage, celery, cress (water), cucumber, dandelion greens, endive (curled and broadleaved), kale, lettuce, mustard greens, radish and rhubarb leaves, shallot (Louisiana, tops and leaf base), spinach, squash (summer scallops and zucchini, both immature), tomato fruits, turnip greens, and watermelon rinds (2 varieties). The highest freezing points of all other vegetables, except certain lots of potatoes, were between 30.0° and 30.9°.

The range in highest freezing points of potatoes held at 55° F. for 60 days or less ranged from 30.2° to 30.5° (table 3).

Special care during storage should be given to vegetables requiring a temperature of 32° F. if their freezing points approach or are above 31°.

ASPARAGUS

The highest freezing points of 2 samples of Mary Washington asparagus stalks were 30.9° F. and 30.4°; the soluble solids were 4.6 and 6.3 percent, respectively. The highest freezing point for crowns of this variety was 30.8°.

BEAN

The range in highest freezing points of snap beans was 30.4° to 30.7° F. The highest freezing points of shelled lima and shelled Dwarf Horticultural beans were 31.0° and 30.4°, respectively. Soluble solids of the Dwarf Horticultural variety were approximately 4 times greater in the shelled beans than in their pods; the freezing point of the beans was lower than that of the pods.

BEET

The highest freezing points of table beet roots ranged from 29.0° to 30.1° F. The range in highest freezing points of beet tops was 30.3° to 31.3°. Soluble solids of the root samples were slightly over twice those of the tops.

CARROT

The highest freezing points of carrots ranged from 28.7° to 29.5° F. The freezing point was appreciably lower and the soluble solids greater in lot 1 than in the other two lots.

CELERY

The highest freezing points of each of 2 lots of celery were 31.1° F. for the outer stalks and 31.6° and 30.8° for the hearts. The pH values of the hearts were somewhat higher than those of the outer stalks. Soluble solids of the outer stalks were less than those of the hearts in both lots. There was no consistent relation between average freezing points and soluble solids.

CORN; SWEET

The highest freezing points of Golden Cross Bantam and Country Gentleman sweet corn were 30.7° and 30.9° F., respectively. The highest freezing point of the husk of Golden Cross Bantam was 30.3°.

LETTUCE

The range in the highest freezing points of 4 varieties or types of lettuce was 31.3° to 31.7° F. The average freezing points usually declined with increases in soluble solids.

MUSKMELON

The range in highest freezing points of 6 kinds of muskmelons was 29.7° to 30.5° F. The lowest soluble solids and highest average freezing point were found in the Persian melon, but there was no definite relation between these factors in the other kinds of melons.

PEA (GARDEN)

The highest freezing point of shelled peas was 29.9° F. and that of the pods 30.9°. The soluble solids value in the shelled peas was 2.2 percentage points higher than that of the pods.

POTATO

Freezing points were determined for 11 varieties of potatoes (table 3).

Freezing points of potatoes held at 55° F. for about 1 to 2 months represent values closely approximating those of freshly dug potatoes. Although potatoes are usually not held at temperatures of 85° and 32°, these temperatures were used to determine how short exposures to a fairly high temperature and a "chilling" temperature affect the freezing points. Freezing points of potatoes previously held at 55° followed by storage at 38° to 40° represent values approximating commercial storage.

The range in highest freezing points of Maine-grown Chippewa, Green Mountain, Kennebec, and Russet Rural varieties, after 2 to 2½ months' storage at 55° F., was 30.2° to 30.5°. The highest freezing points of these varieties after 4 to 5 months at 55°, ranged from 29.4° to 29.9°. Thus, the likelihood of freezing damage to these varieties is slightly less after long storage at 55°.

The highest freezing points of the 4 varieties mentioned were about 1° F. lower in tubers held for about 2 months at 55° followed by 2 months at 38°, as compared with samples held continuously at 55°. The Irish Cobbler and Katahdin varieties also showed lower freezing points after holding at 38°, following storage at 55°.

The soluble solids of Maine Irish Cobbler potatoes stored at 55° F. for 70 days and then transferred to 38° for 23 days showed an increase of 2.0 percentage points as compared with the soluble solids value of tubers held continuously at 55° for 93 days. The soluble solids of North Dakota Triumph tubers stored at 55° for 141 days was 5.6 percent, but the value of another sample of this lot held at 55° for 13 days, followed by holding at 38° for 128 days, was 13.2 percent. The average freezing point of the Irish Cobbler variety declined 0.4° and that of the North Dakota Triumph potatoes 1.6° due to the holding period at 38°. The results of holding immature Sebago and Florida Triumph potatoes from 1 to 15 days at 32° are given in table 3. In the instances mentioned, declines in freezing points due to storage at 38° were evidently associated with increases in soluble solids.

The pH values were somewhat lower in the potatoes subjected to the 38° F. temperature, compared with the pH of tubers held at 55° continuously.

SQUASH

The range in highest freezing points of 7 kinds or varieties of squashes was 29.6° to 31.1° F. The highest average freezing points and the lowest soluble solids were found in the immature summer scallop and zucchini squashes. There was no consistent decline in freezing-point temperatures with an increase in soluble solids in the other kinds or varieties of squashes.

SWEETPOTATO

The range in highest freezing points of 10 varieties of cured sweet-potato roots was 29.0° to 29.7° F. The range in soluble solids was 7.9 to 12.6 percent and the range in average freezing points was 28.7° to 29.4°. There was no consistent relation between soluble solids and average freezing points of the roots. The highest freezing points of Nancy Hall and Porto Rico plants were 29.4° and 30.1°, respectively.

TOMATO

The range in highest freezing temperatures of tomatoes was 30.5° to 31.1° F. Freezing points were very slightly higher for ripe fruits than for either mature-green or turning fruits.

WATERMELON

The highest freezing points of the flesh of 5 varieties of watermelons ranged from 30.5° to 30.9° F.; the range for the rind was 30.7° to 31.3° for 3 of these varieties. Although the range in soluble solids of the flesh of the 5 varieties was wide (4.4 to 10.9 percent) the range in the average freezing points was relatively narrow (30.3° to 30.7°).

Freezing Points of Florist Stocks

Freezing points of 50 or more kinds of cut flowers, foliage, bulbs, rhizomes, tubers, etc., are given in table 4.

The following freezing point groupings suggest only relative resistance to freezing. Certain of these plants or their parts will not tolerate cool temperatures considerably above their freezing points, when growing or when cut. Many plants will tolerate temperatures below their freezing points in nature, but not after cutting. Therefore, the groupings may or may not indicate relative cold hardiness or relative susceptibility to freezing injury.

BULBS, RHIZOMES, ETC.

The highest freezing points of 9 kinds or varieties of bulbs, etc., in ascending order from 27.5° F. to 29.6°, were: Calla, tulip, Regal lily, gladiolus, narcissus (Cheerfulness), dahlia, Madonna lily, hyacinth, and narcissus (Twink). The average freezing points of fancy-leaved caladium, gloxinia, amaryllis, and tuber begonia ranged from 29.7° to 31.1°. The order given is approximate, since the freezing points of other samples might be slightly different.

CUT FLOWERS

The highest freezing points of the petals or other primary decorative parts of certain flowering plants, in ascending order, were as follows: Acacia, 25.6° F.; delphinium, 26.6°; anemone, chrysanthemum, heath, ranunculus, violet, 28.1° to 28.9°; daisy and peony, 29.3° to 29.9°; poinsettia ("flower" leaves), feverfew, rose and aster, sweetpea and snapdragon, camellia, and iris (Dutch), hemerocallis and carnation, 30.1° to 30.8°; amaryllis and cornflower, lily (Ace) and columbine and gardenia, stocks, gladiolus and larkspur, orchid and hyacinth, narcissus, 31.0° to 31.8°.

FOLIAGE

The highest freezing points of the foliage of cut flower plants, of pot plants, and of certain kinds sold as "greens" were as follows in ascending order: Fir, 23.6° F.; acacia, white pine, aspidistra, 24.6° to 24.9°; fern (asparagus and dagger), huckleberry, salal, 26.0° to 26.9°; holly, magnolia, violet, rhododendron, laurel, podocarpus, 27.0° to 27.9°; dracaena, vinca major, iris (Japanese), eucalyptus, asparagus (sprengers), 28.0° to 28.9°; columbine, delphinium, rose, English ivy, poinsettia, 29.1° to 29.9°; carnation, daisy, vinca minor, peony, iris (Dutch), pandanus, chrysanthemum, stocks, caladium, larkspur, feverfew, 30.0° to 30.9°; sanseveria, lily (Ace), amaryllis, hyacinth, gladiolus, and narcissus, 31.0° to 31.6°.

TABLE I.—Freezing points, soluble solids, and pH values of certain fruits and nuts

Kind, variety, and maturity or ripeness ¹	Production area ²	Plant part	Freezing point			Juice analysis		
			Average ³	Lowest	Highest	°F Percent	28.9 14.7	pH
Ambarella ⁴	Florida	Fruit	28.5	27.9	28.8	28.9	28.9	2.7
Apple, fall and winter varieties:								
Close	Maryland	do	28.6	28.4	28.8	28.6	10.7	3.5
Cortland	New York	do	28.3	27.3	28.6	28.7	12.8	4.0
Delicious	Maryland	do	28.2	27.4	28.2	28.2	13.7	3.8
Golden Delicious	do	do	27.8	27.6	28.6	28.0	12.7	3.1
Greening	Washington	do	28.3	27.6	28.8	28.0	12.7	3.1
Grimes Golden	New York	do	28.3	27.5	28.8	28.0	12.7	3.1
Jonathan	Maryland	do	27.6	27.5	28.0	27.5	12.7	3.1
Lady	New York	do	28.0	27.7	28.5	28.0	12.7	3.1
Lodi	Maryland	do	28.5	28.3	28.8	28.7	13.9	3.6
Lowry	Pennsylvania	do	28.5	28.6	28.9	28.9	13.2	4.5
McIntosh	do	do	27.8	27.3	28.3	28.3	12.5	3.4
Opalescent	New York	do	28.4	27.9	28.6	28.6	11.3	3.5
Red Delicious	Maryland	do	27.7	27.5	28.1	28.1	12.8	4.1
Washington	Washington	do	29.7	28.3	30.0	28.0	16.1	3.8
Maryland	Maryland	do	28.2	28.0	28.5	27.2	16.1	3.8
Stayman	do	do	27.1	26.8	27.0	26.3	16.0	3.6
Winesap	Virginia	do	27.0	26.3	28.0	28.0	16.0	3.6
York Imperial	Maryland	do	28.5	27.9	28.8	28.8	13.1	3.9
Apple, summer varieties:								
Gravenstein	Pennsylvania	do	28.5	27.7	29.3	29.3	11.9	3.3
Ramblo	Maryland	do	27.8	27.4	28.3	28.3	11.5	3.2
Apricot:								
Perfection	California	do	28.9	28.6	29.3	29.3	11.6	4.0
Royal	do	do	29.3	29.1	29.6	29.6	13.1	3.9
Tilton	do	do	29.9	29.6	30.1	30.1	13.1	3.9

Avocado:

Booth 1, eating-ripe	Florida	do	do	29.6	29.4	30.0	30.0	7.5
Booth 7, hard-ripe	Florida	do	do	30.2	30.0	30.4	30.4	6.4
Booth 7, eating-ripe	Florida	do	do	31.1	31.1	31.5	31.5	6.4
Booth 7, soft-ripe	Florida	do	do	30.2	29.8	30.6	8.2	6.0
Choquette, ripe	Florida	do	do	30.0	29.8	30.2	5.9	6.2
Collinson, ripe	Florida	do	do	29.5	29.5	30.5	6.6	6.3
Edranol, firm-ripe	Florida	do	do	30.8	30.4	30.9	30.9	6.3
Edranol, ripe	Florida	do	do	30.6	30.3	30.9	30.9	6.3
Fuch, ripe	Florida	do	do	29.0	28.8	29.9	5.6	7.7
Fuerte, nature-green	Florida	do	do	30.0	29.7	30.6	6.9	5.8
Hickson, firm-ripe	Florida	do	do	29.5	29.2	29.6	9.1	6.2
Itzamna, firm-ripe	Florida	do	do	29.3	28.7	29.7	7.4	6.7
Lula, hard-ripe	Lula	do	do	30.1	29.8	31.0	-	-
Lula, ripe	Lula	do	do	29.5	29.3	29.8	-	-
Nabal, firm-ripe	Nabal	do	do	30.4	30.4	30.3	6.3	6.4
Pollock, eating-ripe to ripe	Pollock	do	do	29.8	29.5	30.4	-	-
Taylor, firm-ripe, lot 1	Taylor	do	do	29.5	29.4	30.0	7.1	6.0
Taylor, firm-ripe, lot 2	Taylor	do	do	29.0	28.6	29.1	8.0	6.1
Wagner, ripe	Waldin	do	do	30.3	30.0	30.6	-	6.3
Waldin, ripe	Waldin	do	do	-	-	-	-	-
Banana, Gros Michel:								
Azua, firm-ripe	South America	Flesh	do	28.9	28.9	29.1	5.1	5.2
Changuinole, green	Changuinole	do	do	30.0	29.6	30.4	20.2	4.9
Changuinole, ripe	Changuinole	do	do	29.0	28.6	29.3	5.5	5.2
Fortuna, green	Cuba	Peel	do	30.1	29.8	30.3	5.5	5.2
Fortuna, ripe	Cuba	Flesh	do	30.4	30.3	30.8	3.2	5.9
Guatemala, green	Guatemala	Peel	do	29.1	28.6	29.3	18.3	5.0
Guatemala, firm-ripe	Guatemala	Flesh	do	30.1	29.9	30.3	8.0	5.6
Guatemala, ripe	Guatemala	Flesh	do	30.0	30.0	30.1	5.1	5.3
Santa Marta, green, lot 1	Santa Marta	do	do	28.8	28.4	28.9	11.3	5.5
Santa Marta, ripe, lot 1	Santa Marta	do	do	30.6	30.3	31.0	-	-
Santa Marta, green, lot 2	Santa Marta	do	do	28.6	28.3	28.8	-	-
Santa Marta, ripe, lot 2	Santa Marta	do	do	30.4	30.2	30.6	-	-
		Peel	do	-	-	-	-	-
		Peel	do	-	-	-	-	-

See footnotes at end of table.

TABLE 1.—Freezing points, soluble solids, and pH values of certain fruits and nuts—Continued

Kind, variety, and maturity or ripeness ¹	Production area ²	Plant part	Freezing point			Juice analysis	
			Average ³	Highest	Lowest	Soluble solids	pH
Banana, Plantain, green	Cuba	Flesh	30.3	30.4	29.4	Percent	5.4
Barbados-cherry ⁴	Florida	Fruit	28.8	28.4	29.4	12.1	3.5
Bignay (<i>Antidesma bunius</i>) ⁴	do	do	30.4	30.1	30.6	7.1	3.0
Blackberry:	Maryland	do	30.3	30.3	30.5	Percent	5.4
Black variety	do	do	28.4	28.1	28.6	12.1	3.5
Crystal White ⁵	do	do	29.5	29.3	29.7	do	do
Logan (loganberry) ⁶	New Jersey	do	29.0	28.9	29.3	do	do
Blueberry	do	do	29.4	29.0	29.7	do	do
do	do	do	28.3	28.0	28.5	10.5	6.8
do	do	do	29.1	29.0	29.5	14.7	3.6
North Carolina	Florida	do	26.8	26.1	28.3	12.1	3.6
Calamondin ⁴	do	do	28.2	27.5	28.7	14.5	2.4
Canistel, ripe ⁴	do	do	29.9	29.7	30.0	19.8	5.6
Carambola, green ⁴	do	do	29.8	29.5	30.4	5.9	1.6
Carambola, ripe ⁴	do	do	29.3	29.0	29.4	8.0	2.2
Carissa, red fruit, ripe ⁴	do	do	27.6	27.5	27.7	8.8	3.0
Carissa, black fruit, ripe ⁴	do	do	27.4	26.8	28.0	14.9	5.3
Cherimoya, green ⁴	do	do	27.2	26.4	27.9	20.8	5.2
Cherimoya, ripe ⁴	do	do	do	do	do	do	do
Cherry, sweet:	California	do	27.4	27.0	27.7	16.6	4.0
Black Tartarian, ripe	do	do	26.2	26.0	26.5	22.5	3.9
Bing, ripe	do	do	28.2	27.3	28.8	16.7	4.2
Lambert, ripe	Maryland	do	28.9	28.8	29.0	6.8	3.4
Cherry, sour, Montmorency, ripe	Flesh	do	20.3	18.5	21.8	do	do
Chestnut, American ⁶	Maryland	do	22.3	21.9	22.5	do	do
Chestnut, Chinese	Italy	do	28.8	28.7	28.9	7.0	2.6
Chestnut, Italian	Florida	do	29.0	27.6	29.8	8.6	2.6
Citrangle, Morton ⁴	do	do	do	do	do	do	do

Coconut, lot 1	do	Milk	30.4	5.1
Coconut, lot 2	do	Husk, green	30.6	5.4
Cranberry:		Flesh	28.7	
Early Black	do		24.5	
Howes	do		28.7	
Currant ⁵	do		30.4	
Date, American-grown, cured ⁵	do		30.2	
Barhee	do		30.0	
Deglet Noor	do		28.5	
Hallaway	do		-5.8	
Khadrawi	do		-7.5	
Theory	do		-13.8	
Fig, Mission, fresh ⁵	do		-6.5	
Gooseberry	do		-8.0	
Grape, American or Labrusca type,	do		-3.3	
Concord	do		-5.6	
Grape, European or vinifera type:	do		-2.7	
Almeria	do		+2.2	
Barlinka	do		+0.4	
Cardinal	do		-5.8	
Emperor	do		-8.0	
Malaza	do		-13.8	
Red Malaga	do		-1.0	
Ribier	do		-2.7	
Rish Baba (lady-finger)	do		-26.3	
Sultanina ^a (Thompson Seedless)	do		27.1	
Tokay	do		29.9	
Grapefruit:			27.6	
Duncan, lot 1	do	Milk	30.3	
Duncan, lot 2	do	Husk, green	30.2	
Foster Pink, lot 1	do	Flesh	28.5	
Foster Pink, lot 2	do	Rind	28.1	
			27.8	
			27.7	
			28.0	
			27.6	
			26.9	
			26.7	
			26.5	
			26.2	
			28.3	
			27.9	
			26.8	
			28.9	
			27.8	
			28.3	
			28.0	
			27.7	
			28.1	
			28.9	
			27.7	
			28.1	
			29.5	
			28.8	
			27.7	
			28.2	
			28.6	

See footnotes at end of table.

TABLE 1.—*Freezing points, soluble solids, and pH values of certain fruits and nuts—Continued*

Kind, variety, and maturity or ripeness ¹	Production area ²	Plant part	Freezing point			Juice analysis		
			Average ³	Lowest	Highest	Soluble solids	pH	
<i>Grapefruit—Continued</i>								
Marsh Seedless, lot 1	Florida	Flesh	28.9	28.3	29.5	11.4		
	do	Rind	28.9	28.2	29.5	13.9	5.3	
Marsh Seedless, lot 2	do	Flesh	28.6	27.9	29.3	11.0	3.4	
	do	Rind	27.9	27.5	28.4			
Ruby Red, lot 1	do	Flesh	29.6	29.2	30.0	9.0	2.7	
Ruby Red, lot 2	do	do	29.8	29.2	30.0	9.1	3.3	
	do	Rind	29.3	28.7	29.7			
Thompson Pink Seedless, lot 1	do	Flesh	29.2	28.9	29.6	8.0	2.7	
	do	Rind	27.9	27.4	28.1			
Thompson Pink Seedless, lot 2	do	Flesh	29.0	28.6	29.5	10.2	3.4	
Jambolan, ripe ⁴	do	Rind	28.5	28.1	28.9			
Jujube, Indian ⁴	do	Fruit	28.6	28.5	28.7	13.7	3.5	
Kitembilla ⁴	do	do	29.2	29.0	29.3	12.1	3.1	
Dovyalis hebecarpa	do	do	29.3	29.3	29.4	8.8	2.7	
Kumquat, Nagami, ripe	do	Flesh	28.3	28.3	28.3	13.6	2.8	
Lemon:								
Myers	California	do	29.1	28.1	30.0	7.5	2.6	
Eureka, lot 1	do	do	29.3	29.3	29.4	7.0	2.3	
Eureka, lot 2	do	do	28.5	28.1	28.8	8.9	3.3	
Lime:								
Key, lot 1	Florida	do	28.1	28.0	28.2			
Key, lot 2	do	do	28.1	27.9	28.4	7.5	2.3	
Persian, lot 1	California	do	27.9	27.1	28.6	8.6		
Persian, lot 2	do	do	28.4	28.1	28.9	8.5	3.3	
Persian, lot 3	do	do	28.0	28.0	29.1	7.5	2.3	

Limequat: ⁴	Tavares	Florida	do	29.1	29.1	29.1	29.1
Lakeland	do	do	do	30.1	29.6	30.5	29.1
Long-an ⁴	do	do	do	27.7	27.5	27.9	16.1
Loquat: ⁴	do	do	do	28.6	28.6	28.6	28.1
Oliver	do	do	do	28.6	28.6	28.6	28.1
SES4	do	do	do	28.7	28.2	29.2	11.7
Mandarin, Ponkan	do	do	do	28.7	28.2	29.2	4.0
Mango:							
Haden, hard-ripe	do	Fruit	do	29.6	29.4	29.8	12.0
Haden, ripe, lot 1	do	do	do	29.1	29.0	29.4	15.3
Haden, ripe, lot 2	Cuba	do	do	29.3	28.8	29.9	13.3
Irwin, hard-ripe	Florida	do	do	29.9	29.6	30.3	9.2
Irwin, ripe	do	do	do	29.4	29.3	29.6	13.8
Keitt, firm-ripe	do	do	do	29.4	28.4	29.6	12.1
Lippin, hard-ripe	do	do	do	29.9	29.6	30.0	10.7
Lippin, ripe	do	do	do	29.4	29.0	29.7	13.9
Sensation, firm-ripe	do	do	do	29.2	28.7	29.8	14.5
Sensation, ripe	do	do	do	29.1	28.4	29.5	4.4
Nectarine:							
John River, hard-ripe	California	do	do	30.0	29.5	30.4	3.4
Quetta, hard-ripe	do	do	do	29.8	29.5	30.1	9.3
Quetta, firm-ripe	do	do	do	28.5	29.3	13.1	3.7
Unknown variety	Chile	do	do	29.7	29.4	29.9	10.1
Olive, fresh, green ⁵				28.5	27.7	29.4	3.7
Orange:							
Hamlin, lot 1	Florida	Flesh	do	29.4	28.2	30.6	10.3
Hamlin, lot 2	{ do	do	do	29.4	29.1	30.0	15.7
Honey Murcott	{ do	Rind	do	28.1	27.9	28.5	13.2
Jaffa, lot 1	{ do	Flesh	do	27.5	26.9	28.4	22.0
Jaffa, lot 2	{ do	Rind	do	27.2	27.0	27.4	17.1
King, lot 1	{ do	Flesh	do	27.7	28.0	28.4	17.0
King, lot 2	{ do	Rind	do	29.2	28.4	29.6	11.0
		Flesh	do	28.1	27.4	28.6	10.6
		Rind	do	27.8	28.2	28.7	11.2
			do	28.2	28.0	28.5	3.4
			do	27.3	27.0	27.5	3.2

See footnotes at end of table.

TABLE 1.—*Freezing points, soluble solids, and pH values of certain fruits and nuts—Continued*

Kind, variety, and maturity or ripeness ¹	Production area ²	Plant part	Freezing point			Juice analysis		
			Average ³	Lowest	Highest	Soluble solids	pH	
Orange—Continued			°F	°F	°F	Percent		
Lue Gim Gong, lot 1	{ Florida do	Flesh Rind	27.6	26.7	28.7	12.2	3.5	
Lue Gim Gong, lot 2	{ do do	Flesh Rind	26.4	25.8	26.9			
Parson Brown, lot 1	{ do do	Flesh Rind	26.7	25.9	27.4	12.4	4.4	
Parson Brown, lot 2	{ do do	Flesh Rind	25.6	25.1	26.4			
Pineapple, lot 1	{ do do	Flesh Flesh	28.0	27.5	29.4	11.3	3.5	
Pineapple, lot 2	{ do do	do Rind	29.3	28.8	29.8	10.6	3.7	
Pope Late, lot 1	{ do do	Flesh Rind	27.9	27.3	28.0			
Pope Late, lot 2	{ do do	Flesh Rind	27.7	27.4	28.2	12.4	3.6	
Satsuma		do	29.0	28.5	29.3	11.2	3.6	
Seedling, Florida sweet, lot 1	{ do do	Rind Flesh	28.0	27.5	28.5			
Seedling, Florida sweet, lot 2	{ do do	Rind Flesh	28.6	28.4	28.8	12.7	3.9	
Surprise Navel		do	27.6	26.3	27.6			
Temple, lot 1	{ do do	Rind Flesh	28.6	28.3	29.1	11.6	3.9	
Temple, lot 2	{ do do	Rind Flesh	27.9	27.4	28.2			
Valencia	{ California Florida	do	30.3	29.6	30.5	9.6	4.3	
Valencia, lot 1	{ do do	Rind Flesh	29.3	28.7	29.7			
Valencia, lot 2	{ do do	Rind Flesh	28.7	27.7	29.5	12.7	3.3	
Valencia, lot 3	{ do do	Rind Leaves	29.0	28.6	29.4	12.3	3.5	

Washington Navel, lot 1	do	Flesh-Rind	28.1	28.7	10.6	3.9
	do	Rind	28.3	28.6	14.3	5.6
Washington Navel, lot 2	do	Flesh-Rind	29.7	30.1	10.6	4.2
	do	Rind	28.0	27.6	28.4	
Papaya:						
Blue Solo, ripe	do	Fruit	30.1	29.9	10.7	
Hawaiian Solo, firm-ripe, lot 1	Hawaii	do	30.0	29.6	30.4	
Hawaiian Solo, ripe, lot 1	do	do	30.1	29.9	30.4	
Hawaiian Solo, ripe, lot 2	do	do	30.2	30.0	30.4	
Peach:						
Dixigem, ripe						
Elberta, ripe	do	do	29.7	29.4	29.8	
Elberta, firm-ripe	California	do	29.8	29.2	30.3	
Chile	do	do	29.4	28.9	29.8	
J. H. Hale, ripe	Washington	do	29.7	29.4	30.0	
Red Ceylon, firm-ripe ⁴	Florida	do	29.3	28.8	29.7	
Red Ceylon, ripe ⁴	do	do	29.0	28.4	29.4	
Sullivan Elberta, firm-ripe	South Carolina	do	29.9	29.8	30.2	
Sullivan Elberta, ripe	do	do	30.1	29.9	30.3	
Peanut, Virginia Bush, fresh		Fruit	25.1	23.5	26.9	
Peanut, Spanish, fresh		do	26.3	25.1	28.3	
Pear:						
Anjou, lot 1	California	Fruit	28.6	28.2	29.2	
Anjou, lot 2	do	do	28.5	27.8	29.1	
Bartlett, firm-ripe	Oregon	do	28.0	27.4	28.6	
Bosc, ripe	California	do	28.9	28.7	29.0	
Comice, ripe	do	do	28.0	27.4	28.4	
Flemish Beauty, ripe	Washington	do	28.6	28.4	29.0	
Forrelle, hard	California	do	26.3	25.9	26.7	
Kieffer, firm-ripe	Maryland	do	28.7	28.5	28.8	
Red Bartlett, hard-ripe	Oregon	do	27.4	27.6	27.6	
Red Bartlett, ripe	do	do	28.6	28.3	29.0	
Russel Bosc, firm-ripe	California	do	27.6	26.9	28.0	
Russel Bosc, ripe	do	do	27.7	27.1	28.0	
Seckel, large type, ripe, lot 1	Oregon	do	27.2	26.6	27.6	
Seckel, large type, ripe, lot 2	do	do	27.0	26.8	27.4	
Seckel, large type, ripe, lot 3	do	do	26.5	25.5	27.5	
Seckel, small type, hard-ripe	Pennsylvania	do	26.9	27.1	27.4	
Winter Nelis, hard-ripe ⁵		do	27.2	27.1	27.5	
Winter Nelis, soft-ripe ⁵		do	27.5	27.1	28.1	

See footnotes at end of table.

TABLE 1.—*Freezing points, soluble solids, and pH values of certain fruits and nuts—Continued*

Kind, variety, and maturity or ripeness ¹	Production area ²	Plant part	Freezing point			Juice analysis		
			Average ³	Lowest	Highest	Soluble solids	pH	Percent
Pecan, Schley ⁵		Flesh	19.6	19.9	19.9			
Persimmon, Hachiya, hard-ripe	California	Fruit	27.5	27.0	28.1	19.8		5.4
Pineapple:								
Abakka	Florida	Flesh	29.9	29.7	30.1	15.1	3.2	
Pernambua	do	do	30.0	29.7	30.2	12.3	3.1	
Red Spanish, hard-ripe	Cuba	do	29.4	29.2	29.5	14.2	3.5	
Red Spanish, ripe	{ do	do	29.8	29.5	30.0	11.6	3.3	
Queen	Florida	Leaves	29.8	29.4	30.0	6.3	4.7	
Plum:		Flesh	29.5	29.4	29.7	17.0	3.4	
Beauty, firm-ripe	{ California	Fruit	29.8	29.3	30.5	8.0	3.0	
Beeky Smith, ripe	do	do	29.0	28.6	29.3	10.5	3.1	
Damson, firm-ripe	do	do	28.8	28.5	29.3	10.0	2.9	
Duarte, ripe	do	do	28.5	28.4	28.7	13.8	3.3	
Eldorado, firm-ripe	do	do	28.7	28.2	29.0	12.3	3.4	
Green Gage, firm-ripe	do	do	29.0	28.9	29.6	14.3	4.2	
Green Gage, ripe	do	do	29.4	29.0	29.7	9.0	3.3	
Italian prune, ripe	Oregon	do	29.0	28.6	29.5	11.8	3.3	
President, firm-ripe	California	do	27.7	27.5	28.0	14.9	3.5	
Santa Rosa, firm-ripe	do	do	27.2	26.3	27.7			
Pomegranate	do	do	28.6	28.3	29.0	12.4		
Prickly pear ⁴	do	do	26.5	26.4	26.6	16.6	3.2	
Pummelo:								
Nakon	Florida	Flesh	28.7	28.3	29.1	10.6	3.4	
Thong Dee	do	Fruit	27.5	26.9	27.9	12.9	3.3	
Quince ⁵			28.1	28.4	28.0			

Ramontchi, ripe ⁴	Florida	do	28.3	10.0	3.7
Raspberry:					
Columbian ⁶	Maryland	do	28.8	28.2	3.8
Cumberland	Maryland	do	29.9	29.9	3.8
Latham ⁵	Maryland	do	29.8	29.7	3.2
September	Maryland	do	30.8	30.7	3.2
Sapote: ⁴					
White	Florida	do	28.4	27.9	28.6
Black, mature-green	do	do	28.0	27.2	18.4
Black, ripe	{	do	27.6	26.9	5.4
Star-apple ⁴	do	Foliage	24.2	24.0	5.1
Strawberry:	do	do	29.2	28.6	4.6
Arnoire, ripe	Maryland	do	30.1	30.0	6.1
Bellmar, ripe	Maryland	do	30.4	30.3	3.4
Big Joe ⁵	Maryland	do	30.0	29.8	3.4
Blakemore, plants	{				
Blakemore, green	Maryland	Roots	29.6	29.3	3.2
Blakemore, ripe	do	Fruit	28.8	28.3	3.2
Catskill, ripe	do	do	30.4	30.3	3.2
Dixieland, ripe	do	do	30.5	30.6	3.2
Dorsett ⁵	do	do	30.1	29.9	3.6
Fairfax, ripe	Maryland	do	29.8	29.5	3.6
Klondyke ⁵	Maryland	do	29.6	29.4	3.6
Midland, green	Maryland	do	29.6	29.3	3.2
Midland, ripe	do	do	30.4	30.3	3.6
Mission, ripe	do	do	30.2	30.0	3.6
Pocahontas, green	do	do	30.4	30.3	3.5
Pocahontas, ripe	do	do	30.3	30.1	3.3
Premier ⁵ , ripe	do	do	30.3	30.4	3.3
Red Star, ripe	Maryland	do	29.6	30.4	3.4
Sparkle, ripe	do	do	30.1	30.2	3.4
Stelemaster, ripe	do	do	30.1	30.0	3.6
Tennessee Beauty, ripe	do	do	30.2	30.3	3.5
Tennessee Shipper, ripe	do	do	30.3	30.4	3.3
Vermilion, ripe	do	do	30.5	30.6	3.6
			30.1	30.2	3.6

See footnotes at end of table.

TABLE I.—*Freezing points, soluble solids, and pH values of certain fruits and nuts—Continued*

Kind, variety, and maturity or ripeness ¹	Production area ²	Plant part	Freezing point			Juice analysis	
			Average ³	Lowest	Highest	Soluble solids	pH
Tangelo:			°F	°F	°F	Percent	
Minneola, lot 1	{ Florida	Flesh	27.6	27.2	28.0	11.3	3.7
	do	Rind	26.1	26.0	26.4		
Minneola, lot 2	{ do	Flesh	28.8	28.1	29.8	10.8	3.6
	do	Rind	26.5	25.5	26.8		
Orlando, lot 1	{ do	Flesh	28.2	27.0	29.0	10.0	3.3
	do	Rind	28.1	27.6	28.7	14.0	5.2
Orlando, lot 2	{ do	Flesh	29.7	29.1	30.1	9.7	3.7
	do	Rind	28.3	27.6	28.9	15.6	5.2
Seminole, lot 1	{ do	Flesh	27.6	26.9	28.3	11.8	3.1
	do	do	29.3	28.5	29.7	11.0	3.2
Seminole, lot 2	{ do	Rind	27.5	27.3	28.0		
	do	Flesh	28.3	27.3	29.0	9.3	3.6
Thornton, lot 1	{ do	Rind	28.2	27.6	28.4	15.9	5.5
	do	Flesh	29.6	29.0	30.3	9.0	3.6
Thornton, lot 2	{ do	Rind	27.9	27.3	28.5		
Tangerine:							
Cleopatra	{ do	Flesh	29.3	28.8	30.0	14.5	3.0
Dancy, lot 1	{ do	do	29.5	28.3	30.1	9.5	3.5
	do	do	29.7	29.7	29.7		
Dancy, lot 2	{ do	Rind	28.6	28.3	28.8	14.5	5.1
Tamarind, mature-green ⁴	{ do	Flesh	24.3	23.3	25.4		
Tamarind, ripe ⁴	{ do	do	24.1	23.8	24.4		
Walnut, Persian (English) ⁵	{ do	do	20.0	19.0	22.1		
Walnut, Chinese ⁵	{ do	do	26.4	25.4	27.0		

¹ Botanical names are used only to distinguish species. Varieties are given if known. "source" names and areas so listed. Most of the fruits were of commercial picking maturity unless otherwise noted.

² Where a type or variety was grown in two production areas, any differences in freezing points are not necessarily due to the effect of the locality where grown.

³ Average based on all individual specimens or composite bundles frozen.

⁴ Grown to a limited extent commercially or for home use only.

⁵ Data from USDA Circular 447, "The Freezing Temperatures of Some Fruits, Vegetables, and Florists' Stocks," 1942, revised by WRIGHT, R. C. These data were obtained with a manually operated potentiometer.

TABLE 2.—*Freezing points, soluble solids, and pH of certain vegetables*

Kind, variety, and maturity or ripeness	Production area ¹	Plant part	Freezing point			Juice analysis		
			Average ²	Lowest	Highest	Soluble solids	pH	
Artichoke, Globe		Scales	°F 29.6	°F 29.4	°F 29.9	Percent 8.1	5.6	
Asparagus:		Upper stalks	30.5	30.0	30.9	4.6	6.3	
Mary Washington, lot 1		do	30.3	30.0	30.4	6.3	7.4	
Mary Washington, lot 2		Crowns	30.5	29.9	30.8	-	-	
Mary Washington		Shelled beans	30.8	30.5	31.0	14.8	6.2	
Bean, lima		Shelled beans	30.9	30.9	30.9	-	-	
Bean, shell, Dwarf Horticultural		Pods	30.0	29.7	30.4	17.6	6.2	
Bean, snap:		Flesh	30.0	29.8	30.4	6.7	6.2	
Black Valentine		do	30.2	29.9	30.5	4.8	6.2	
Green, unknown variety		do	30.3	30.0	30.6	4.8	6.0	
Wax, unknown variety, lot 1		Edible roots	30.5	30.3	30.7	5.0	6.5	
Wax, unknown variety, lot 2		do	29.9	29.7	30.1	-	-	
Beet, table, lot 1		Tops	28.6	28.2	29.0	9.2	6.5	
Beet, table, lot 2		Edible roots	31.2	31.0	31.3	3.7	6.5	
Beet, table, lot 3		Tops	30.2	30.0	30.3	4.6	8.2	
Broccoli, Italian, lot 1		Petioles	29.5	29.4	29.7	9.3	7.3	
Broccoli, Italian, lot 2		Buds	30.4	30.3	30.5	3.3	7.5	
Broccoli rabi		Stalks	29.9	29.9	29.9	-	-	
Brussels sprouts		do	30.1	29.9	30.3	5.3	6.8	
Cabbage:		Leaves	30.9	30.9	30.9	4.2	6.5	
Jersey Wakefield		Buds	31.0	30.6	31.3	5.4	6.1	
Red Drumhead		Heads	30.2	29.7	30.5	9.2	5.7	
See footnotes at end of table.		South Carolina	30.0	29.8	30.4	7.3	6.0	
		do	31.0	30.3	31.7	6.2	6.5	

TABLE 2. Freezing points, soluble solids, and pH of certain vegetables—Continued

Kind, variety, and maturity or ripeness	Production area ¹	Plant part	Freezing point				Juice analysis		
			Average ²		Highest	Soluble solids			
			°F	°F	°F	Percent			
Carrot, lot 1		Roots	28.4	28.3	28.7	11.8	6.2		
Carrot, lot 2		do	29.1	28.6	29.5	8.9	6.2		
Carrot, lot 3		do	28.9	28.4	29.4	9.0	6.6		
Cauliflower	California	Curds	30.1	29.9	30.3				
Geleriae	do	do	30.4	30.4	30.6	5.8	7.4		
Geleriae		Edible roots	30.2	30.0	30.3	5.3	6.2		
Geleriae		Outer stalks	30.9	30.7	31.1	3.3	5.9		
Geleriae		Hearts	31.1	31.0	31.6	4.0	6.2		
Geleriae		Outer stalks	30.9	30.6	31.1	1.8	6.2		
Geleriae		Hearts	30.7	30.6	30.8	2.1	6.5		
Geleriae		Tops	30.4	30.4	30.4	6.1	5.7		
Geleriae		Bulbs	29.6	29.4	30.0				
Geleriae		do	30.0	29.8	30.3				
Geleriae		Leaves	30.2	29.9	30.6				
Gherkin, or Muscat:		Kernels	30.8	30.4	30.9	18.7	6.3		
Muscati arménacum		do	30.7	30.7	30.7	17.8			
Muscati plumosum		Husk	29.9	29.7	30.3				
Collards	New Jersey	Leaves	30.3	29.7	30.4				
Corn, sweet:	Maryland	do	31.3	31.2	31.4				
Country Gentleman, milk stage		Flesh	29.9	29.7	30.3				
Golden Cross Bantam, milk stage		do	30.7	30.5	30.7				
		do	31.0	30.9	31.1				
Cress:		Leaves	31.2	31.0	31.4				
Upland cress			30.3	29.7	30.4	10.9	5.9		
Water cress			31.3	31.2	31.4	2.1	6.1		
Cucumber, unknown varieties			29.9	29.7	30.3	3.3	5.8		
	Cuba		30.7	30.5	30.7	3.7	5.8		
	Cuba		31.0	30.9	31.1	3.0	5.9		
Dandelion		Leaves	31.2	31.0	31.4	4.2	6.1		
Dasheen, Trinidad type			30.0	29.9	30.3	6.3	6.2		
Dan-			30.4	30.2	30.9	2.8	5.9		

Eggplant, Black Beauty	{ Florida do	30.3	30.6	4.4	
Endive, curled (chicory)	do	30.4	30.2	5.6	5.5
Endive, broad-leaved (escarole)	do	30.9	30.6	3.2	6.2
Fennel, Florence	do	31.3	31.1	2.4	7.1
Garlic	do	31.0	30.1	7.1	5.9
Horseradish	do	30.7	30.4	3.8	5.5
Kale	do	31.7	31.6	2.0	6.8
Kohlrabi ³	do	30.0	29.9	6.3	6.3
Leek	do	30.2	30.0	6.9	6.3
Lettuce:					
Bibb	do	27.3	26.6	38.5	5.4
Big Boston	do	26.3	25.9	26.8	5.2
California	do	30.3	30.3	30.5	5.2
Iceberg type	do	28.5	28.1	28.7	5.3
Romaine, or Cos	do	30.7	30.6	31.1	5.1
Mushroom, cultivated	do	30.0	29.7	30.2	6.2
Muskmelon:					
Casaba, firm-ripe	do	31.4	31.3	31.7	2.5
Crenshaw, ripe	do	31.2	31.1	31.3	6.0
Honey Dew, hard-ripe	do	31.5	31.4	3.3	6.1
Honey Dew, ripe	do	31.0	30.8	31.7	6.2
Persian, firm-ripe	do	31.2	31.0	31.4	6.3
Pride of Wisconsin, ripe	do	31.5	31.2	31.7	6.4
Spanish "honeydew,"	do	30.0	29.6	30.4	7.0
Mustard, "greens" type	do	30.1	29.6	30.4	6.8
New Jersey	Leaves	29.9	29.6	30.1	12.6
Oka	Leaves	29.5	29.5	30.1	6.0
Cuba	Pods	29.8	29.3	30.1	9.7
		30.0	29.3	30.3	10.3
		30.2	29.7	30.5	6.5
		29.6	29.3	29.9	13.6
		29.5	29.2	29.7	10.5
		31.0	30.6	31.4	6.3
		28.6	28.3	28.7	6.1

see footnotes at end of table.

TABLE 2.—Freezing points, soluble solids, and pH of certain vegetables—Continued

Kind, variety, and maturity or ripeness	Production area ¹	Plant part	Freezing point			Juice analysis	
			Average ²	Lowest	Highest	Soluble solids	pH
Onion:			°F	°F	°F	Percent	
Bunch or spring		Enlarged bases	30.1	30.0	30.4	8.1	6.4
Italian Red		Bulbs	30.2	30.0	30.4	9.0	5.4
Texas Bermuda		do	30.0	29.9	30.2	8.6	6.2
Yellow Bermuda		do	30.2	29.7	30.6	7.3	5.4
Parsley		Leaves and petioles	29.7	29.6	30.0	5.3	6.0
Parsnip		Roots	30.1	29.9	30.4	8.3	6.0
Pea, garden		do	29.5	29.2	30.0	15.2	7.1
Pea, garden		Shelled peas	29.7	29.4	29.9	13.0	6.6
Pea, garden		Pods	30.5	30.3	30.9	10.8	5.4
Pepper, sweet, green		Flesh	30.5	30.4	30.6	5.0	7.1
Pepper, chili		do	30.5	30.4	30.7	5.0	6.5
Potato, ⁴		Flesh and seeds	30.9	30.8	30.9	—	—
Pumpkin, Connecticut Field	Maryland	Flesh	29.9	29.3	30.5	5.7	6.4
Radish:		Roots	30.1	29.8	30.5	4.2	6.4
Red Breakfast		Leaves	31.2	31.0	31.3	4.7	6.3
White Icicle		Roots	30.3	30.0	30.7	2.6	6.0
Rhubarb, lot 1		Leaves	30.8	30.6	31.0	—	—
Rhubarb, lot 2		Stalks	30.0	29.8	30.3	4.7	3.4
Rutabaga, American Purple-top type	Canada	Leaves	30.7	30.4	30.9	4.5	3.3
Salsify		Roots	29.7	29.4	30.3	3.4	4.2
Shallot		Tops	30.1	29.3	30.1	8.0	6.2
Squash:	Louisiana	Roots	29.6	29.3	30.4	5.9	6.2
Acorn, mature	do	Green tops	31.6	31.3	31.7	10.8	5.5
Butternut, mature	do	White bulb-bases	31.4	31.1	31.6	2.7	5.7
Spinach	France	Dry bulbs	29.9	29.8	30.0	15.4	5.3
Squash:	Florida	do	29.2	29.0	29.5	16.9	5.5
Acorn, mature	do	Leaves	31.3	31.1	31.5	4.5	6.3
Butternut, mature	do	Flesh	30.0	29.5	30.5	8.6	6.9
		do	29.8	28.9	30.1	6.4	6.6

Summer Scallop, immature	Maryland	do	30. 9	30. 8	31. 1	3. 4	6. 3
Warty Hubbard, immature	do	do	29. 8	29. 4	30. 3	5. 1	6. 3
Yellow Crockneck, immature	do	do	30. 5	30. 1	30. 8	4. 8	6. 4
Yellow Straightneck, mature	do	do	29. 5	29. 4	29. 6	5. 0	6. 4
Zucchini, mature	do	do	30. 6	30. 4	30. 7	5. 4	6. 2
Zucchini, immature	do	do	30. 9	30. 7	31. 1	3. 8	6. 3
Sweetpotato, cured:							
Allgold	Maryland	Roots	29. 3	29. 3	29. 5	9. 8	5. 4
Goldrush	do	do	28. 9	28. 6	29. 4	10. 5	6. 1
Jersey Orange	do	do	29. 3	29. 0	29. 7	10. 7	5. 9
Maryland Golden	do	do	28. 9	28. 6	29. 2	12. 5	6. 0
Nancy Hall	Georgia	Plants or slips	29. 4	29. 4	29. 4		
Maryland	do	Roots	29. 3	29. 2	29. 6		
Orange Little Stem	do	do	28. 7	28. 5	29. 0	10. 1	6. 0
Porto Rico	North Carolina	do	29. 3	28. 7	29. 7	7. 9	5. 9
Sunnyside	Maryland	do	29. 4	29. 0	29. 6	10. 4	6. 0
Virginia	Georgia	Plants or slips	30. 0	29. 9	30. 1		
Yellow Jersey	Maryland	Roots	29. 2	28. 7	29. 4	9. 3	5. 9
Tomato:	do	do	29. 3	29. 1	29. 4	10. 5	5. 9
Homestead, turning	Florida	Fruit	30. 1	29. 9	30. 5		
Homestead, ripe	do	do	30. 2	29. 7	30. 7	4. 7	4. 3
Rutgers, mature-green	do	do	30. 6	30. 3	31. 0	4. 8	4. 1
Rutgers, ripe	do	do	30. 8	30. 3	31. 1	4. 7	4. 2
Turnip:							
Purple-Top White Globe	Roots	29. 8	29. 5	30. 1	5. 2	6. 2	
Unkown variety—"greens"	Tops	30. 3	30. 1	30. 4	4. 6	6. 0	
Watermelon:	Leaves and petioles	31. 5	31. 2	31. 7	9. 8	6. 4	
Charleston Gray, ripe	South Carolina	do	30. 4	30. 3	30. 5	9. 6	5. 4
Congo, ripe	do	do	31. 0	30. 6	31. 3		
Fairfax, ripe	Virginia	do	30. 5	30. 4	30. 6	7. 8	5. 5
"Ice Box"	Georgia	do	30. 7	30. 7	30. 7	2. 6	5. 6
New Hampshire Midget, ripe	California	do	30. 4	30. 3	30. 6	10. 9	5. 6
	do	do	31. 2	31. 2	31. 3	6. 0	5. 3
	do	do	30. 7	30. 1	30. 9	4. 4	5. 7

¹ Where 1 kind or variety of vegetable was grown in 2 or more production areas, any differences in freezing points are not necessarily due to the effect of the locality where grown. Dashes in this column follow commodities for which production area information was not available.

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TABLE 3.—Changes in freezing points, soluble solids, and pH of potatoes due to storing at various temperatures for different periods

Variety and lot	Production		Original storage		Subsequent storage		Freezing point			Juice analysis	
	State	Temperature	Period	Temperature	Period	Temperature	Average ^a	Highest	Lowest	Soluble solids	pH
Chippewa	Maine	°F. 55	Days 60	°F. 55	Days 60	°F. 55	°F. 30.3	°F. 29.4	°F. 30.1	Percent 30.4	
	do	55	145	55	145	55	29.6	29.2	29.1	29.9	
	do	70	38	do	75	75	29.2	28.7	28.6	29.5	
	do	63	55	63	55	55	30.1	29.9	29.8	30.2	
Green Mountain, lot 1	do	147	55	147	55	70	29.5	29.1	29.1	29.8	
Green Mountain, lot 2	do	70	38	do	77	77	28.9	28.6	28.6	29.1	
Irish Cobbler, lot 1	do	55	26	do	55	55	30.0	30.0	30.0	30.3	
Irish Cobbler, lot 2	do	63	55	do	63	63	30.3	30.2	30.2	30.5	
Irish Cobbler, lot 3	do	93	55	do	93	93	29.9	29.6	29.6	30.3	
North Dakota	Maine	°F. 55	Days 70	°F. 55	Days 38	°F. 55	29.5	29.2	29.2	29.8	
	do	55	19	do	23	19	30.5	30.3	30.3	30.4	
	do	60	55	do	70	55	30.3	30.3	30.3	30.4	
Katahdin, lot 1	Maine	°F. 55	63	do	63	63	30.0	29.2	29.2	30.4	
	do	112	55	do	112	55	30.1	30.0	30.0	30.5	
	do	71	55	do	71	71	29.5	29.0	29.0	30.0	
	do	19	55	do	19	19	29.1	28.8	28.8	29.8	
Katahdin, lot 2	Maine	°F. 55	125	do	125	125	30.1	29.9	29.9	30.3	
	do	170	55	do	170	170	30.0	29.9	29.9	30.1	
Katahdin, lot 3	Maine	°F. 55	40	do	40	40	24	29.9	29.9	30.1	
	do	60	55	do	60	60	30.0	29.9	29.9	30.3	
Kennebec, lot 1	Maine	°F. 55	140	do	140	140	30.3	30.2	30.2	30.5	
	do	70	55	do	70	70	29.7	29.4	29.4	29.8	
Kennebec, lot 2	Maine	°F. 55	20	do	20	20	28.9	28.9	28.9	29.5	
	do	126	55	do	126	126	30.3	30.2	30.2	30.4	
	do	170	55	do	170	170	30.1	29.9	29.9	30.3	
	do	130	55	do	130	130	30.0	29.9	29.9	30.2	

Red Pontiac, lot 1	California	30.0	29.5	30.3	7.4	6.1
Red Pontiac, lot 2	North Dakota	55	60	30.4	30.2	30.9
Russet Burbank, lot 1	Maine	55	20	30.1	29.7	6.0
Russet Burbank, lot 2	do	55	65	30.0	29.7	6.0
Russet Rural, lot 1	do	55	141	30.2	30.1	30.3
Russet Rural, lot 2	Florida	do	55	71	28.7	29.4
Sebago, immature, lot 1	do	do	55	26	28.5	29.0
Sebago, immature, lot 2	do	do	32	1	30.1	30.0
Triumph, immature, lot 1	do	do	32	1	30.4	30.3
Triumph, immature, lot 2	do	do	32	15	29.9	30.5
White Rose	California	55	60	29.6	29.2	29.9
White Rose	North Dakota	55	60	29.9	29.8	30.1
White Rose	do	do	85	1	30.4	30.3
White Rose	do	do	32	1	30.4	30.3
White Rose	do	do	32	13	30.1	29.9
White Rose	do	do	60	1	30.1	29.8
White Rose	North Dakota	55	60	30.4	30.1	30.9
White Rose	do	55	141	30.0	29.9	5.6
White Rose	do	55	13	38	128	28.6
White Rose	California	55	6	29.5	29.9	6.0

¹ Average based on all individual specimens frozen.

TABLE 4.—Freezing points of certain florist or nursery stocks.

Kind, variety, and production area ¹	Plant part	Freezing point		
		Average ²	Lowest	Highest
Acacia, California	Flowers	25.2	25.0	25.6
	Leaves	24.4	24.3	24.6
Amaryllis	Bulbs ⁴	30.8	—	—
	Leaves ⁵	31.0	—	—
Anemone	Petals ⁵	28.1	28.0	28.2
Aspidistra	Leaves ⁵	24.9	—	—
Aster, California	Petals	30.1	30.1	30.3
Begonia, tuber-rooted	Tubers ⁴	31.1	—	—
Caladium, fancy-leaved	Bulbs ⁴	29.7	—	—
	Leaves	30.9	30.8	30.9
	Petioles	31.1	31.1	31.1
Calla	Bulbs ⁵	27.5	27.5	27.5
Camellia japonica, Maryland:				
Governor Mouton	Petals	30.4	30.3	30.6
Pink Perfection	do	30.3	30.1	30.5
Purity	do	30.6	30.4	30.7
Carnation	Calyxes	30.0	29.9	30.1
	Leaves	30.0	29.9	30.0
	Petals	30.6	30.4	30.8
	Stems	29.1	29.1	29.1
Chrysanthemum	Leaves ⁵	29.6	28.7	30.5
	Petals ⁵	28.4	28.0	28.7
Columbine	Flowers ⁵	31.1	—	—
	Leaves ⁵	29.1	—	—
Cordyline, terminalis	do ⁵	28.0	—	—
Cornflower	Petals	30.9	30.9	31.0
Dahlia	Roots ⁵	28.3	28.0	28.7
Daisy, shasta	Leaves ⁵	30.0	—	—
	Petals ⁵	29.3	—	—
Delphinium	Leaves ⁵	29.2	—	—
	Petals ⁵	26.6	—	—
Dracaena:				
Fragrans, var. massangeana	Leaves	29.1	—	—
Sanderiana	do	28.2	—	—
Episcia ²				
Eucalyptus, California	Leaves	28.5	28.4	28.8
Fern:				
Asparagus, Florida	Fronds (cladodes)	25.8	25.5	26.0
Oregon Dagger	Fronds	28.6	28.5	28.9
Sprengers, Florida	Fronds (cladodes)	26.5	26.4	26.9
Feverfew	Flowers	30.2	30.1	30.2
	Leaves	30.9	30.9	30.9
Fir, balsam, Canada	Needles	23.4	23.3	23.6
Gardenia	Petals	30.8	30.5	31.0
Gladiolus:				
	Bud sheaths	30.5	—	—
	Buds, unopened	31.3	—	—
Valeria, Florida	Leaves	30.9	30.5	31.4
	Petals	31.3	31.3	31.3
	Spikes, tips	31.7	—	—
Mixed varieties, Netherlands	Corms	28.0	27.6	28.2
Gloxinia	Bulbs ⁴	30.5	—	—
Heath	Flowers ⁵	28.7	28.7	28.7
	do ⁵	30.8	—	—
Hemerocallis	Leaves ⁵	26.3	23.9	27.0
Holly, American	do	26.5	26.3	26.7
Huckleberry, Oregon	—	—	—	—

See footnotes at end of table.

TABLE 4.—Freezing points of certain florist or nursery stocks—Continued

Kind, variety, and production area ¹	Plant part	Freezing point		
		Average ⁶	Lowest	Highest
Hyacinth, Netherlands:				
Pink Pearl	Bulbs	28.7	28.7	29.0
City of Haarlem	do	28.9	28.6	29.3
Unknown variety	{ Flowers	31.3	31.1	31.4
	{ Leaves	31.1	30.9	31.3
Iris:				
Dutch	{ Flowers	30.5	30.4	30.6
	{ Leaves	30.1	30.0	30.2
German	do ⁴	27.6		
Japanese	{ Flowers ⁵	30.5		
	{ Leaves ⁵	28.7		
Ivy, English, Maryland	do	29.8	29.6	29.9
Larkspur, annual	{ Flowers	31.0	30.8	31.3
Laurel, Maryland	{ Leaves	30.9	30.9	30.9
Lily:				
Ace	{ Flowers	31.0	31.0	31.1
	{ Leaves	30.9	30.8	31.0
Madonna, France	Bulbs	28.7	28.1	28.9
Regal (Royal)	do ⁵	27.1	27.0	27.8
Magnolia grandiflora	Leaves	26.7	26.6	27.0
Mistletoe, Texas	{ Berries	23.9	23.0	25.0
Narcissus, Paper White	{ Leaves	22.5	22.0	23.0
Narcissus:	Bulbs ⁵	28.9	28.2	29.3
Cheerfulness, Netherlands	do	28.0	27.6	28.6
Mrs. Krelage, Maryland	{ Leaves	31.6	31.6	31.6
Twink, Netherlands	{ Flowers	31.6	31.5	31.8
Orchid, Cattleya	Bulbs	29.3	29.2	29.6
Pandanus	Flowers	31.1	30.9	31.4
	Leaves ⁵	30.4		
Peony, Festiva Maxima	{ Flowers	29.9	29.9	29.9
Pine, white	{ Leaves	30.0	29.9	30.1
Podocarpus, Florida	Needles	24.7	24.6	24.8
Poinsettia:	Leaves and stems	27.5	27.0	27.9
Red variety	{ Flower leaves (bracts)	30.0	29.9	30.1
	{ Green leaves	29.5	29.1	29.9
	{ Stems	28.4	28.1	28.6
White variety	{ Flower leaves (bracts)	30.0		
Ranunculus	Flowers ⁵	28.6	28.2	28.9
Rhododendron	Leaves	27.5	27.3	27.6
Rose:				
Better Times, lot 1	{ do	29.6		
	{ Petals	30.2	30.0	30.3
Better Times, lot 2	{ Leaves	29.5	29.5	29.5
	{ Petals	31.1	30.9	31.2
Rubber, variegated	Leaves ⁵	30.3		
Saintpaulia ³	do			
Salal, Oregon	do	26.5	26.4	26.8
Sanseveria laurentii	do ⁵	31.0	31.0	31.0
Sidalcea, rosea, Maryland	do	29.3		
Snapdragon	Flowers	30.3	30.1	30.4
Statice latifolia, Maryland	Leaves	26.3		

See footnotes at end of table.

TABLE 4.—*Freezing points of certain florist or nursery stocks—Continued*

Kind, variety, and production area ¹	Plant part	Freezing point		
		Average ⁶	Lowest	Highest
Stocks:			° F	° F
Pink	Flowers	30.9	30.6	31.2
White	do	31.2	31.0	31.3
Mixed varieties	Leaves	30.5	30.3	30.7
Sweet Pea, mixed colors	Flowers	30.4	30.4	30.4
Tulip, Netherlands:				
Fantasy	Bulbs	27.2	26.9	27.5
Prunus	do	27.4	27.3	27.6
Violet, African ³				
Violet, sweet	{ Flowers ⁵	28.5	28.2	28.8
	{ Leaves ⁵	27.4		
Vinca:				
Major	do ⁵	28.6		
Minor, Maryland	do	29.9	29.8	30.0

¹ Varieties and production areas are given if known. Common names are used except for items known in the trade by botanical names.

² The results from 2 thermocouples for each of 3 varieties of episcia leaves gave highest freezing points ranging from 29.6° to 30.3° F.

³ Using only 1 thermocouple for each of 11 varieties of saintpaulia leaves (African violet), the range in freezing points was from 29.6° to 30.7° F.

⁴ Data from USDA Handbook 66, "The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks," WRIGHT, R. C., ROSE, DEAN H., and WHITEMAN, T. M. These data were obtained with a manually operated potentiometer.

⁵ Data from USDA Circular 447. These data were obtained with a manually operated potentiometer. See footnote 5, table 1.

⁶ Average based on all individual specimens or composite bundles frozen.

